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ABSTRACT

This chapter outlines the theory of cost-benefit analysis and discusses its application to determining the cost-benefit of instructional development projects. Three types of applications are discussed: (1) descriptive applications of single projects; (2) predictive studies of proposed projects; and (3) comparative analysis of alternative projects and alternative approaches to a single project. Problems involved in current approaches to the cost-benefit analysis of instructional projects are discussed, and the COST-ED model, which was developed to deal with these projects, is presented. Finally, problems still unresolved in this field are considered. The text is supplemented with 12 figures, and a 28-item bibliography is provided. (Author/EW)

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CHAPTER X

ECONOMIC EVALUATION IN/OF INSTRUCTIONAL DEVELOPMENT

By

Gene L. Wilkinson

It does not take an extensive presentation to convince educators that they are in the midst of a crisis involving educational cost and effectiveness. The newspapers are full of reports of the failure of school bond issues, of the reluctance of legislatures to fund university budget increases, of falling SAT scores, and of law suits which charge malpractice when school graduates are unable to read and write. Many groups and individuals have suggested that technology, both as machine and as technique, might contribute positively to the solution of the problem of rising costs combined with falling productivity (Carnegie Commission, 1972; Commission on Instructional Technology, 1970; Committee for Economic Development, 1968; Scanlon, 1973). One suggestion is to transform the present labor intensive educational system into one which is capital intensive. The possible effect of such a change is illustrated in Figure 1 (adapted from Wilkinson, 1972). Presently schools are devoting a high percentage of their total budgets to salaries. If this emphasis were to be shifted so that a higher percentage of current budgets were allocated to either auxiliary staff and services or instructional software, hardware, and facilities, there should be an increase in the total productivity of the school system. Such an increase, however, must be considered hypothetically because there is little factual knowledge about the productivity of educational media or about the cost and effectiveness of instructional development (Wilkinson, 1973). Caffarella (1975), in an examination of over 300 references dealing with the cost-effectiveness of educational media, found only 32 which were based on empirical data. Lee (1972) found that instructional development programs in institutions of higher education did not employ strategies designed to evaluate cost-effectiveness. A conference dealing with the implementation of instructional development through learning resource programs found that one of the major problems facing such programs is economic; specifically, that of insuring the cost-effectiveness of their instructional development programs (Halloway, 1974).

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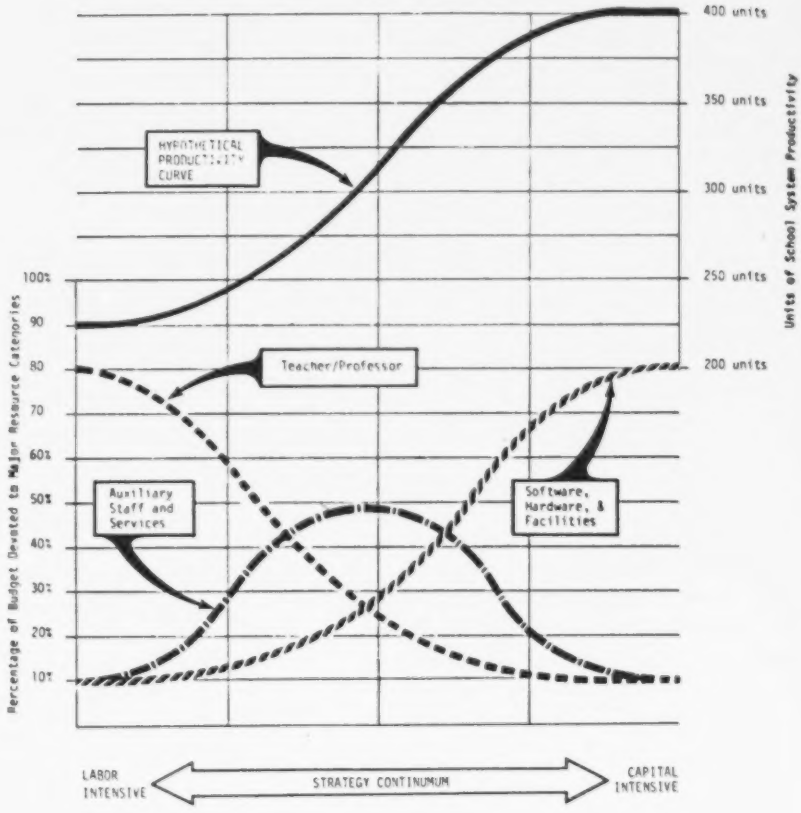
Figure 1. Effect of Changing Strategies of Productivity



OBJECTIONS TO ECONOMIC EVALUATION

The lack of valid economic evaluations of the effectiveness of instructional development can be blamed on a number of factors. Questions of instructional cost-effectiveness are considered to be somewhat illegitimate by academicians (Newman, 1971). Administrators are under too great a pressure to produce immediate improvements to be concerned with the long-range evaluation necessary to demonstrate cost-effectiveness (Temkin, 1974). The effort to gain accurate cost information is itself a large cost item (Belmore, 1972). The major problem inhibiting the application of economic evaluation strategies within education, however, is a lack of understanding of the approach and of the concepts upon which it is based (Kaufman and Cohn, 1972). Some of these misconceptions should be examined in detail before we move into a general discussion of the potential relationship of economic evaluation strategies to the instructional development process.

COST EVALUATION BOILS DOWN TO "PICK THE CHEAPEST WAY TO DO IT"

The aim of cost evaluation strategies is not to pick the "cheapest" alternative but rather to pick the most economical. This requires that the objectives or outputs to be obtained must be clearly and fully defined. With the output defined, it should be possible to determine the approach which provides either the most output for a set cost or which provides a set level of output for the least cost – this being the definition of economic efficiency. The concern in economic evaluation is the balance of cost and effectiveness, not just the cost.

BECAUSE OF ALL THE COMPARATIVE MEDIA STUDIES WHICH SHOW CONFLICTING RESULTS OR NO-SIGNIFICANT-DIFFERENCE, THIS STILL MEANS "PICK THE CHEAPEST"

It might be reasonable to say that since there is no-significant-difference in student performance between students who listened to a lecture and students who viewed a mediated presentation, educational efficiency can be improved by simply increasing the number of students enrolled in a particular class or section. However, there is reason to doubt the validity of the comparative media studies. For example, Hartley (1966) examined 112 studies which compared programmed instruction to conventional instruction. When he had eliminated those studies which did not meet minimal requirements for comparative studies, he was left with only six valid studies; these studies not only showed significant differences but tended to support each other. In many of the studies comparing film or television with conventional instruction, the measure of effectiveness was performance on standardized tests. As Popham (1973) points out, such tests are designed to

reduce the effects of different instructional strategies. Also, few of the studies made any attempt to identify interactions between treatments and student characteristics. The area of comparative media studies is still open and needs to be re-examined by educational researchers.

ECONOMIC EVALUATION TAKES THE DECISION-MAKING PROCESS OUT OF THE HANDS OF THE RESPONSIBLE ADMINISTRATOR AND TURNS IT OVER TO A TECHNICIAN

The analyst does not make decisions. He works within parameters set up by the developer and decision maker. He merely provides information to the decision maker. Since so many aspects of educational cost have not been adequately defined, since many of the desired outcomes of education cannot be quantified, and since so many political factors must be taken into consideration in making educational decisions, there is a high degree of uncertainty in the economic evaluation of educational alternatives. At best these evaluation strategies provide a basis for comparing alternatives, thereby making explicit the currently intuitive decision-making process.

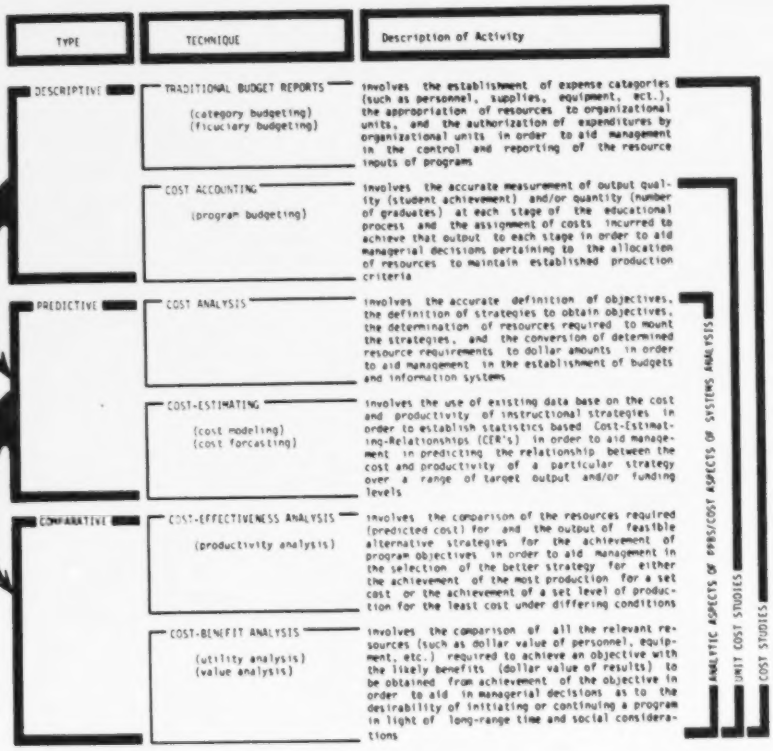
THERE ARE SO MANY DIFFERENT TERMS AND TECHNIQUES THAT IT ISN'T POSSIBLE TO KEEP TRACK OF THEM, LET ALONE USE THEM PROPERLY

To many, this would seem to be a valid objection. Terms such as cost-effectiveness, cost analysis, cost estimating, cost-benefit, utility analysis and cost modeling are often used interchangeably and improperly (McCullough, 1966). Many studies in education which claim to be cost-effectiveness reports are in fact reports of cost and effectiveness. When used with proper precision, however, the various costing terms point out some useful distinctions in terms of intents, techniques, and points of application.

INTENT OF TECHNIQUE

In order to clarify some of the differences among the different costing techniques which are available for use by the instructional developer, a system is presented in Figure 2 which classifies and interrelates most of the terminology currently being used to describe aspects of economic evaluation (adapted from Wilkinson, 1972, 1973). The various costing techniques can be divided into three broad categories on the basis of the intent of the analysis: descriptive, predictive, or comparative.

Figure 2. Classification System for Costing Techniques


TYPE
TECHNIQUE
Description of Activity
DESCRIPTIVE
TRADITIONAL BUDGET REPORTS
(category budgeting)
(fiduciary budgeting)
involves the establishment of expense catagories (such as personnel, supplies, equipment, ect.), the appropriation of resources to organizational units, and the authorization of expenditures by organizational units in order to aid management in the control and reporting of the resource inputs of programs
COST ACCOUNTING
(program budgeting)
involves the accurate measurement of output quality (student achievement) and/or quantity (number of graduates) at each stage of the educational process and the assignment of costs incurred to achieve that output to each stage in order to aid managerial decisions pertaining to the allocation of resources to maintain established production criteria
PREDICTIVE
COST ANALYSIS
involves the accurate definition of objectives, the definition of strategies to obtain objectives, the determination of resources required to mount the strategies, and the conversion of determined resource requirements to dollar amounts in order to aid management in the establishment of budgets and information systems
COST-ESTIMATING
(cost modeling)
(cost forcasting)
involves the use of existing data base on the cost and productivity of instructional strategies in order to establish statistics based Cost-Estimating-Relationships (CER's) in order to aid management in predicting the relationship between the cost and productivity of a particular strategy over a range of target output and/or funding levels
COMPARATIVE
COST-EFFECTIVENESS ANALYSIS
(productivity analysis)
involves the comparison of the resources required (predicted cost) for and the output of feasible alternative strategies for the achievement of program objectives in order to aid management in the selection of the better strategy for either the achievement of the most production for a set cost or the achievement of a set level of production for the least cost under differing conditions
COST-BENEFIT ANALYSIS
(utility analysis)
(value analysis)
involves the comparison of all the relevant resources (such as dollar value of personnel, equipment, etc.) required to achieve an objective with the likely benefits (dollar value of results) to be obtained from achievement of the objective in order to aid in managerial decisions as to the desirability of initiating or continuing a program in light of long-range time and social considerations
ANALYTIC ASPECTS OF PPBS/COST ASPECTS OF SYSTEMS ANALYSIS
UNIT COST STUDIES
COST STUDIES

DESCRIPTIVE STUDIES

Descriptive cost studies are the essential first step in developing a sound basis for determining the economic viability of instructional technology and of instructional development. Such studies seek to describe the costs of existing projects or programs. A distinction is made in this category between traditional budgeting and cost accounting.

Traditional budgeting lumps all expenses into such categories as salaries and wages, supplies and expenses, capital and travel. These categories are subdivided horizontally on the lowest administrative unit level but there is normally no attempt to allocate expenses on the course or project level where the outputs of the educational system are generated. Such budgets can allow cost comparisons between departments, programs, or schools and are useful in insuring the legal authorization and control of expenditures, but they tell us little about the "true" cost of instructional technology and often hide more information than they provide.

Cost accounting or program budgeting techniques seek to allocate cost items to the program elements that generate measurable output units. Under such a system, a single professor's salary might be split so that portions are applied to several different courses, research projects, or public service activities. Educational cost accounting systems can be quite complex. Wilkinson (1971), in developing a program budget system for a large university media program, was able to identify 117 separate output generating elements without conducting the analysis on the level of individual courses or projects. This complexity is why so few universities utilize more than a very simple program budget format. Most often there is only an attempt to analyze costs into such broad areas as instruction, research, and public service.

PREDICTIVE STUDIES

The second category of cost studies are those which seek to predict the costs of proposed systems. There are two major categories of predictive studies – cost analysis, which identifies the resources needed by and, therefore, the costs of a pre-defined system that operates at a set level of effectiveness, and cost-estimating, which employs statistical regression techniques with existing cost data in order to predict a range of costs over a number of output levels for a particular strategy. Although there are some major differences between the two types of predictive studies which will be discussed in detail in a later section, they share some common characteristics. Both techniques involve the accurate definition of objectives and the design of systems which will achieve these objectives.

COMPARATIVE STUDIES

The final category of cost studies are those which seek to compare alternatives in a systematic manner. These comparative studies are based on the predictive studies which, in turn, are based upon the descriptive studies. Within this category, a distinction is made between cost-effectiveness studies, which compare alternative ways of achieving a particular objective, and cost-benefit studies, which compare the costs of achieving alternative objectives against the benefits to be obtained from achieving these objectives.

Such comparisons are not as complex as the economic terminology employed in them often leads us to assume. We are constantly using these techniques on an intuitive basis. When an individual goes to a professional convention and decides to sit in on one of the presentations, he is making an intuitively based cost-benefit decision. The value to be obtained from listening to the speaker is greater than the value that could be obtained from other ways in which he could be spending his time, such as attending some other presentation, viewing the exhibits, or sharing a cup of coffee with a friend. In the same situation, if it were essential that the individual obtain the information that the speaker was going to present, but he had the option of either picking up a copy of the formal paper or listening to the verbal presentation, he is faced with a cost-effectiveness decision. Which of the available means of achieving the objective of gaining the information costs the least in terms of time, energy, or expense? The obvious choice in such a situation would be to pick up a copy of the paper. However, there is often much to be gained from the informal interchange between the speaker and his audience in such presentations. If this is part of the objective to be achieved, it needs to be stated as a part of the objective. The careful statement of objectives is one of the key points in performing any economic evaluation. The next section will look at this and other points in more detail.

TECHNIQUES OF COST-EFFECTIVENESS EVALUATION

Cost-effectiveness analysis is used to evaluate, and choose between, alternative means of achieving a specific objective. Such an analysis can proceed from either of two orientations — the achievement of an established output level for the least cost or the achievement of the most output for a set level of cost. No matter which approach is employed, there are a number of fundamental operations which need to be carried out in any properly designed cost-effectiveness evaluation: (1) determination of objectives, (2) determination of viable alternatives, (3) determination of relevant costs, and (4) presentation and interpretation of results. The first two of these operations are most properly the domain

of the instructional developer, rather than that of the cost analyst. However, there are some requirements which these two operations must meet if the economic evaluation is to be valid. It is necessary, therefore, to look briefly at these operations before turning to the determination and presentation of the cost data, which is the prime concern of the cost analyst.

DETERMINATION OF OBJECTIVES

The first step in any cost-effectiveness evaluation is the definition of the objectives that are to be achieved by the alternatives to be considered. The statement of objectives should include the following: (1) the outputs to be obtained from the system, (2) the inputs available to the system, and (3) the units by which both outputs and inputs are to be measured. The statement of objectives should not include anything, such as the specification of presentation formats, which might limit the total number of options which might be included in the analysis.

The major problem with cost-effectiveness analysis in instructional development activities is the selection of the output measures. Most studies that have been conducted have employed economic measures – such as number of graduates, number of student-contact-hours, or student-credit-hours – rather than measures of educational effectiveness. This is largely the result of assuming that there are no significant differences among students' performances which are attributable to differences in presentation strategy. Also, there is difficulty in relating measures of cognitive and non-cognitive behavioral change to changes in system input levels for the purpose of comparison. When the differences in learning or affective behavior for individual students are used in the evaluation, variations in total output levels are derived by the combination of such behavioral measures with some economic output indicator, e.g., number of students X average score on a standardized examination. Such measures should become more common as the methodology of educational cost-effectiveness evaluation is developed. For example, Segal (1976) has reported on a current study of CAI which uses marginal annual costs per achievement gain per child as the objective measure.

DETERMINATION OF VIABLE ALTERNATIVES

The second step in a cost-effectiveness evaluation is the determination of alternative instructional strategies which could be employed to achieve the objectives and which, therefore, will be compared in the study. At first, the designer would want to consider the total universe of possibilities – limited only by his knowledge and imagination. But this universe of possibilities is rapidly reduced through consideration of those constraints which serve to limit his options when dealing with

real-world problems. Some of the constraints which serve to limit the available options are as follows (adapted from Judy, 1969):

IMAGINARY CONSTRAINTS: limits imposed by the inability or unwillingness of individuals to consider alternatives which are outside of their realm of experience;

TECHNOLOGICAL CONSTRAINTS: limits imposed by a consideration of what current technology can achieve;

POLICY CONSTRAINTS: limits imposed by decisions made at other levels in the organization;

POLITICAL CONSTRAINTS: limits imposed, or thought to be imposed, by the larger public;

ORGANIZATIONAL/LEGAL CONSTRAINTS: limits imposed by the division of power, rights, and responsibilities among various bodies;

RESOURCE CONSTRAINTS: limits imposed by unavailability of one or more of the resources required for certain alternatives;

TARGET CONSTRAINTS: limits imposed by a commitment to achieve a particular goal or level of effectiveness.

An explicit listing of presentation requirements is developed through a consideration of the constraints. The alternatives that meet the criteria of the statement of presentation requirements would be the "viable" alternatives which would be evaluated in the analysis.

In many cases, one of the constraints under which we operate is the prior choice of one of the media alternatives to be evaluated – for example, CAI. However, to say that CAI is to be one of the alternatives is not enough. CAI is a fairly broad term which can mean a large number of things – in terms both of the software that is to be displayed and the hardware configurations upon which the display is to be presented. There are at least ten major variations of computer-based delivery systems – ranging from a basic minimum specified by the definition of CAI (a form of individualized instruction that employs digital computer technology to manage and display information, accept student responses, provide knowledge of results, and select subsequent learning events), through variations of the PLATO IV and TICCIT systems, Computer Managed Instruction, and computer simulation/gaming configurations (Wilkinson, 1976). If CAI is to be one of the alternatives, the form and format of its configuration must be clearly specified.

The need for clear definition of the CAI configuration is even more important when it comes to determining the alternatives against which it is to be compared. The comparison is to be with "viable" alternatives. What are viable alternatives to CAI? This would be determined by both the project objectives and the constraints under which the project is operating. If the project calls primarily for rote drill and practice,

an alternative could be a linear programmed text or a simple workbook. In this case, CAI would probably be a poor choice from a cost-effectiveness point of view. However, if the project called for taking advantage of the flexibility, memory capacity, and fast response capabilities of the computer in order to produce "infinitely" branching programs providing individually shaped, corrected, and reinforced programs taking into consideration the needs, knowledge, and prejudices of each learner, clearly alternatives other than workbooks need to be considered. Traditional instruction – the self-contained classroom using one teacher with 20–25 students, and using various textbooks and aids – does not provide this sort of flexibility and, therefore, should not be one of the alternatives considered. Possibly a tutor, working on a one-to-one basis (provided that this tutor has the same grasp of the subject field and the various ways in which it can be misunderstood and mastered as does the team of design and subject specialists who developed the CAI program) would be able to provide such an alternative. Another possible alternative would be Individually Prescribed Instruction.

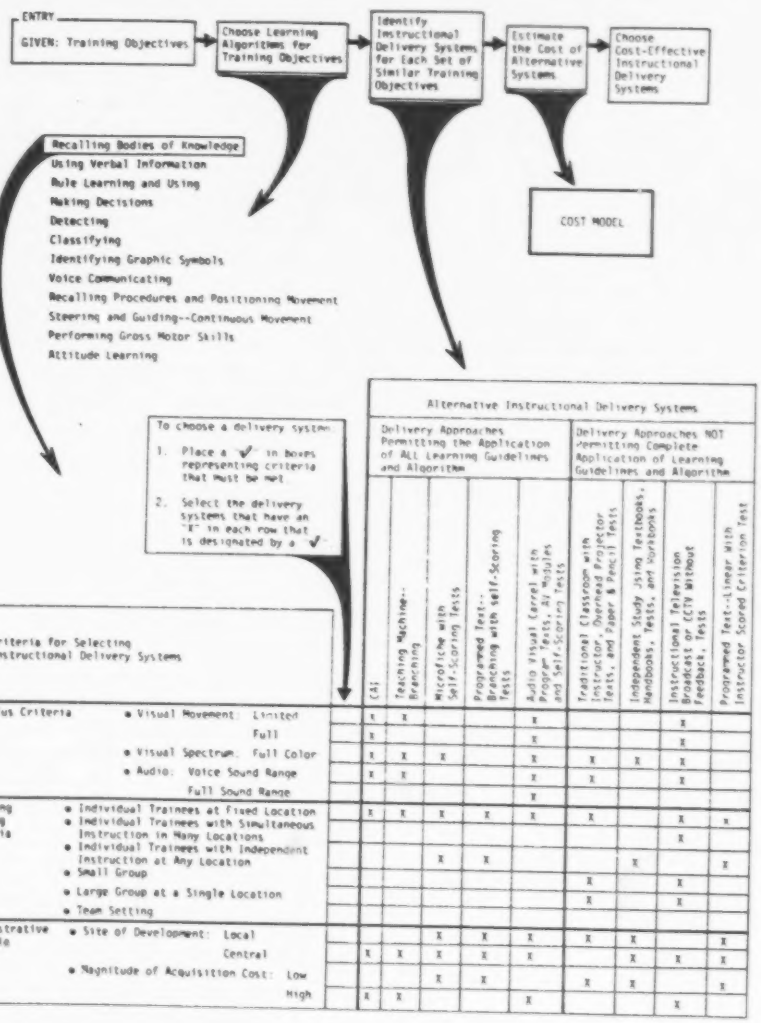
A number of systematic procedures for identifying the comparable viable alternatives have been developed for use in the design of military training systems (Hess, 1975; Braby, 1975). Figure 3 presents an overview of the system developed for the Navy by Braby, *et al.* Starting with the training objectives, the analyst/designer selects the appropriate algorithm (type of learning) called for by each objective. For each of the 12 algorithms, a selection matrix which identifies the stimulus characteristics of media systems appropriate to the algorithm has been developed. Figure 3 presents the matrix for the "recalling bodies of knowledge" algorithm. The analyst marks the criteria which must be met in the appropriate column and checks the rows to determine which of the alternate delivery systems will be considered in the analysis. The procedure then calls for the analyst to feed such information as number of students, sections, time required, etc., into a computer-based cost model which computes costs for each of the alternatives being considered. Other methods of computing system costs will be considered in the following section.

DETERMINATION AND PRESENTATION OF RELEVANT COSTS

Once the alternatives to be compared have been listed, it is necessary to establish the relative cost and productivity of each. Two different techniques can be employed: cost analysis and cost-estimating.

Cost analysis can proceed from one of two approaches, fixed-effectiveness or fixed-cost. In the fixed-effectiveness approach, a target level of effectiveness is established. Those systems are defined which would employ each of the alternatives under consideration and which

Figure 3. Cost-Effectiveness Media Selection Procedure


ENTRY
GIVEN: Training Objectives
Choose Learning Algorithms for Training Objectives
Identify Instructional Delivery Systems for Each Set of Similar Training Objectives
Estimate the Cost of Alternative Systems
Choose Cost-Effective Instructional Delivery Systems
COST MODEL
Recalling Bodies of Knowledge
Using Verbal Information
Rule Learning and Using
Making Decisions
Detecting
Classifying
Identifying Graphic Symbols
Voice Communicating
Recalling Procedures and Positioning Movement
Steering and Guiding--Continuous Movement
Performing Gross Motor Skills
Attitude Learning
To choose a delivery system:
1. Place a ✓ in boxes representing criteria that must be met
2. Select the delivery systems that have an "X" in each row that is designated by a ✓
Alternative Instructional Delivery Systems
Delivery Approaches Permitting the Application of ALL Learning Guidelines and Algorithm
Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm
CAI
Teaching Machine--Branching
Microfiche with Self-Scoring Tests
Programmed Text--Branching with self-Scoring Tests
Audio Visual Carrel with Program Texts, AV Modules and Self-Scoring Tests
Traditional Classroom with Instructor, Overhead Projector Texts, and Paper & Pencil Tests
Independent Study Using Textbooks, Handbooks, Tests, and Workbooks
Instructional Television Broadcast or CCTV Without Feedback, Tests
Programmed Text--Linear With Instructor Scored Criterion Test
Criteria for Selecting Instructional Delivery Systems
Stimulus Criteria
• Visual Movement: Limited
Full
• Visual Spectrum: Full Color
• Audio: Voice Sound Range
Full Sound Range
Training Setting Criteria
• Individual Trainees at Fixed Location
• Individual Trainees with Simultaneous Instruction in Many Locations
• Individual Trainees with Independent Instruction at Any Location
• Small Group
• Large Group at a Single Location
• Team Setting
Administrative Criteria
• Site of Development: Local
Central
• Magnitude of Acquisition Cost: Low
High

would produce at the established level of effectiveness. The resources, such as personnel and equipment, which would be needed to develop and maintain each system are then determined and converted to dollar costs at the current market price, producing a total dollar cost for each alternative. The problem of choice then becomes one of selecting the least expensive alternative. The fixed-cost approach on the other hand, requires the analyst to determine, for a set level of funding, the productivity of different systems, each of which employs one of the alternatives under consideration. The problem of choice under this approach is to select the most productive alternative. Presentation of the results of the evaluation is relatively simple when cost-analysis techniques are employed – a one page summary of the results would be more than adequate.

The determination of the cost estimate through cost analysis can become a highly complex cost accounting task. This complexity can be appreciated by examining the cost model for instructional television presented in Figure 4 (adapted from Walter, 1969). The major problem with cost analysis estimates is that the estimate produced is a single-point figure rather than a continuous function over variations in output. The output of the alternatives that are being evaluated would probably not vary linearly over different rates of input. This would lead to different orders of preference among them at different levels of funding. Therefore a new estimate must be made if the projected funding level is changed or if a different level of output is selected.

Cost-estimating seeks to avoid the major problem of cost analysis by establishing a continuous prediction function for each alternative over a range of possible output levels. These prediction functions are termed Cost-Estimating-Relationships (CERs). The CERs are derived by means of standard procedures of regression analysis applied to historical data from systems similar to the alternatives under consideration. As illustrated in Part A of Figure 5, existing data on the cost and productivity of similar systems are plotted on a scattergram and the line of best fit is determined. Assuming that the assumptions necessary to employ regression analysis have been met, the line of best fit produces a continuous curve displaying the predicted values of input or system cost over the range of possible system output levels. Similar CERs are then developed for the other alternatives under consideration.

The balance sheet approach to the presentation of the results that was employed with the cost analysis approach to cost-effectiveness evaluation is not feasible when cost-estimating relationships are used. The continuous nature of such projections cannot be readily conveyed through raw figures. With such projections, a graphic decision model,

Figure 4. Cost Prediction Model for Instructional Television

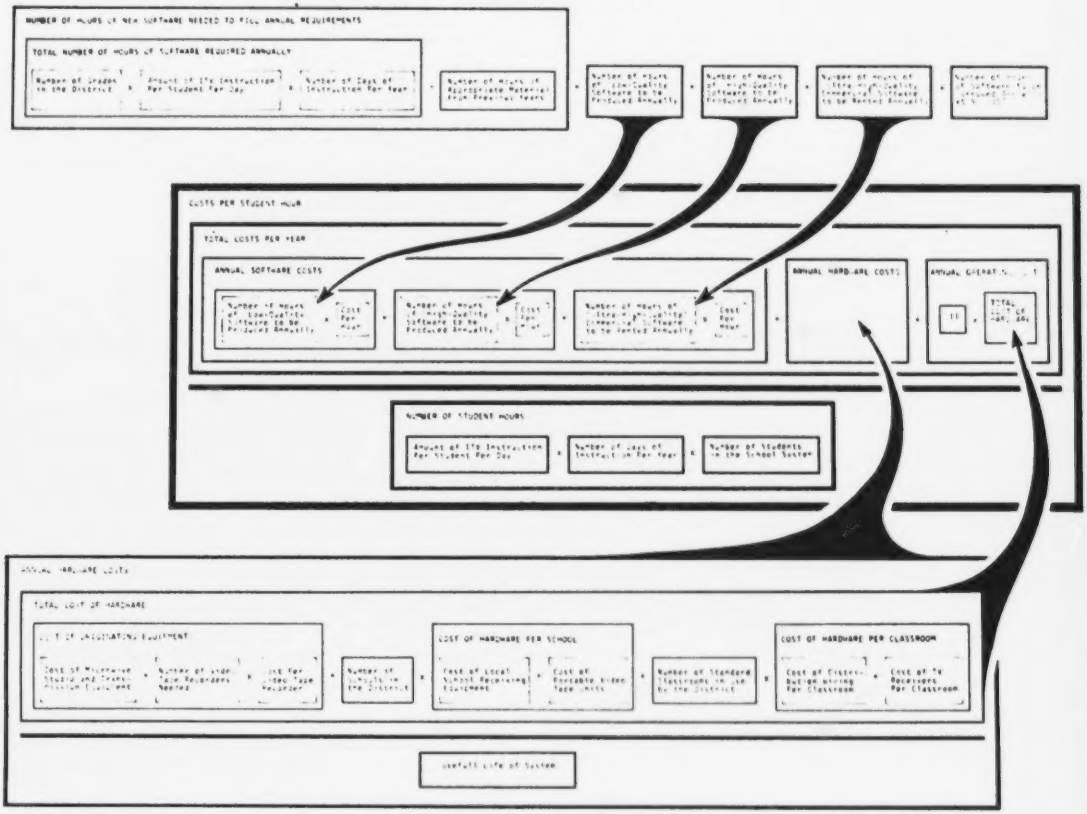

NUMBER OF HOURS OF NEW SOFTWARE NEEDED TO FILL ANNUAL REQUIREMENTS
TOTAL NUMBER OF HOURS OF SOFTWARE REQUIRED ANNUALLY
Number of Grades in the District
Amount of ITV Instruction Per Student Per Day
Number of Days of Instruction Per Year
Number of Hours of Appropriate Material from Previous Years
Number of Hours of Low-Quality Software to be Produced Annually
Number of Hours of High-Quality Software to be Produced Annually
Number of Hours of High-Quality Software to be Rented Annually
COSTS PER STUDENT HOUR
TOTAL COSTS PER YEAR
ANNUAL SOFTWARE COSTS
Number of Hours of Low-Quality Software to be Produced Annually
Cost Per Hour
Number of Hours of High-Quality Software to be Produced Annually
Cost Per Hour
Number of Hours of High-Quality Software to be Rented Annually
Cost Per Hour
ANNUAL HARDWARE COSTS
ANNUAL OPERATING COSTS
Total Cost of Hardware
NUMBER OF STUDENT HOURS
Amount of ITV Instruction Per Student Per Day
Number of Days of Instruction Per Year
Number of Students in the School System
ANNUAL HARDWARE COSTS
TOTAL COST OF HARDWARE
COST OF CIRCULATING EQUIPMENT
Cost of Microwave Studio and Transmission Equipment
Number of Videotape Recorders Needed
Cost for Videotape Recorder
Number of Schools in the District
COST OF HARDWARE PER SCHOOL
Cost of Local School Receiving Equipment
Cost of Portable Video Tape Units
Number of Standard Classrooms in Use by the District
COST OF HARDWARE PER CLASSROOM
Cost of Distribution Wiring Per Classroom
Cost of TV Receivers Per Classroom
Useful Life of System

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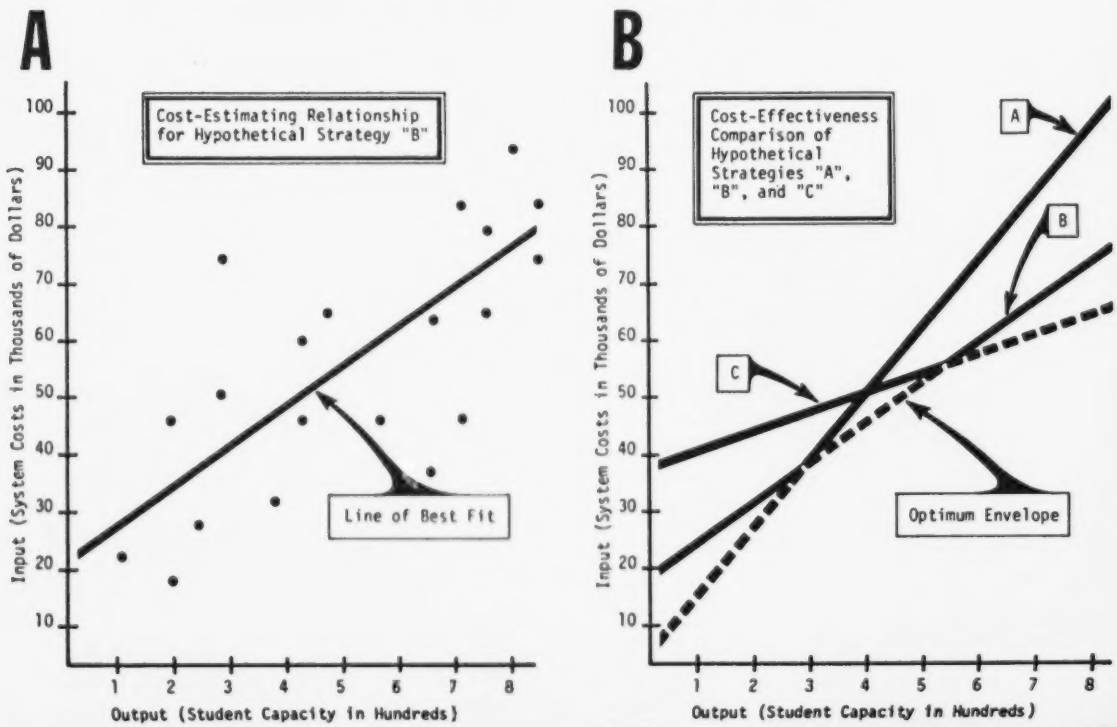
Figure 5. Determination and Presentation of Cost-Estimating Relationships

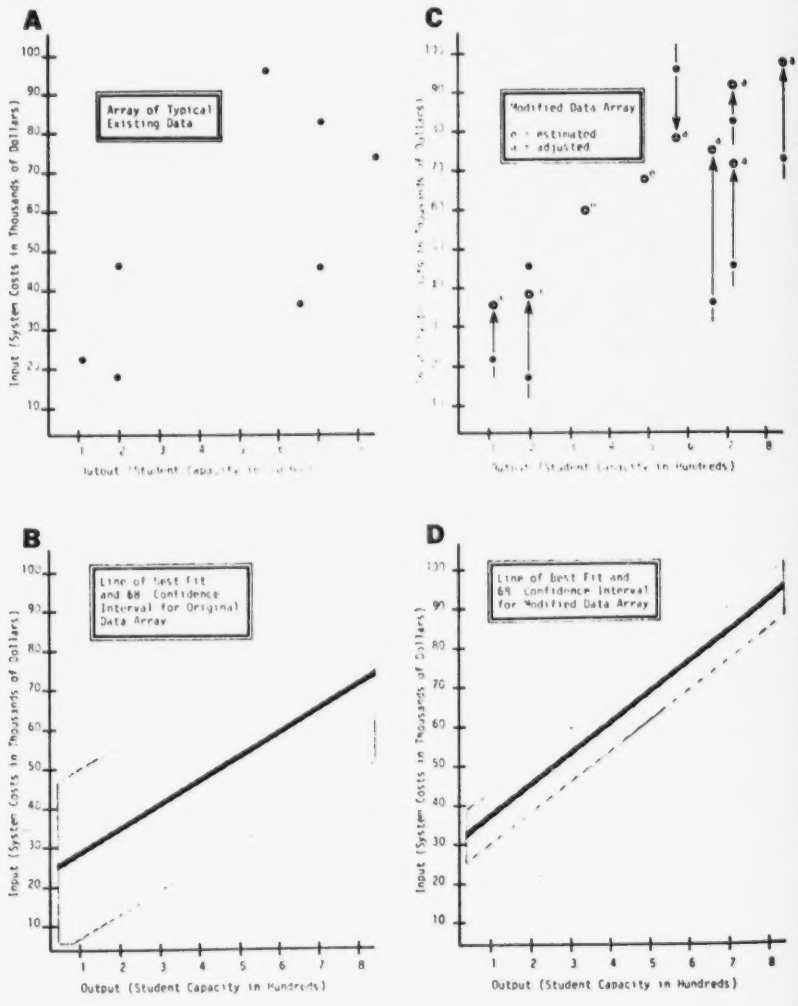


such as the one shown in Part A of Figure 5 should be prepared. The CERs for the three different alternatives which are being evaluated are shown as lines "A", "B", and "C" on the model. Using these functions, it is possible to draw an envelope of optimum choice (shown as a broken line in Figure 5B) which identifies the "best" choice of strategies for any level of desired output or at any level of available funding. In this example, alternative "A" would be the better choice for any system with a capacity of less than 300 students or for any budget under $35,000. For a system with a capacity of from 300 to 550 students, alternative "B" is the better choice. Alternative "C" is the better choice for any system with a capacity of over 550 students or for a budget of over $55,000. The effects of using cost analysis to evaluate these alternatives can be seen by examining the data presented in Figure 5A. If a fixed-effectiveness approach, with a target level of 700 students, had been selected, the alternatives would have rated "C" first with "B" and "A" following in that order. If a fixed-cost approach, with a set budget of no more than $45,000, had been selected, the order of preference among the alternatives would have been "B" first followed by "A" and then "C".

The use of cost-estimating-relationships has a number of advantages over the use of cost analysis techniques. A number of problems, however, are associated with their use. Often, for example, the line of best fit which can be derived from the historical data is curved rather than straight which calls for the use of complex curve-fitting techniques. In a strategy which has a large capital investment for implementation, but for which there is only minor increments in cost per student as the capacity of each major component is approached, the CER is more likely to take the form of stair steps with sloping platforms. Other difficulties arise with respect to the data base from which the estimates are derived. The information may be in the wrong format (requiring, for example, the conversion of existing output data from student contact hours to number of graduates) or the cost categories employed in the various historical studies may vary (requiring an examination of the detailed cost figures as well as the total system cost) and very likely the data were generated at different points in time (requiring, at least, adjustments for inflation or other changes in the market value of resources). Such problems greatly increase the difficulties encountered by the analyst and affect the reliability of the values calculated through the use of CERs.

The problems caused by inadequate or missing data when using CERs is illustrated in part B of Figure 6. Using the data presented in Figure 6A, the standard error of estimate was determined and a 68% confidence interval (gray area in Figure 6B) was plotted on the line of best fit. If such confidence intervals were plotted on the decision model

Figure 6. Determination and Improvement of Confidence in CERs


A
Array of Typical Existing Data
Input (System Costs in Thousands of Dollars)
C
Modified Data Array
e = estimated
a = adjusted
B
Line of Best Fit and 68 Confidence Interval for Original Data Array
Input (System Costs in Thousands of Dollars)
Output (Student Capacity in Hundreds)
D
Line of Best Fit and 69 Confidence Interval for Modified Data Array
Input (System Costs in Thousands of Dollars)
Output (Student Capacity in Hundreds)

presented in Figure 5B, the decision-maker would be faced with a situation where no one alternative was clearly the "best" choice at any level of cost or of output. This problem can be reduced both through the estimation of costs to fill gaps and through adjustment to the existing data base. The effects of such an adjustment to the data presented in 6A is illustrated in Parts C and D of Figure 6. However, as can be seen from this example, cost-effectiveness evaluations must always be viewed as aids to decision-making rather than as a decision-maker themselves.

TECHNIQUES OF COST-BENEFIT EVALUATION

The second major type of comparative cost study, cost-benefit analysis, is concerned with the comparison of the costs of various alternatives with the benefits to be obtained from them. In the business world, such information is provided by profit-and-loss statements. In education and other areas of governmental activity, however, a substitute for the profit/loss approach must be found. That substitute is cost-benefit evaluation.

In its pure form, such an evaluation requires that the output from each of the alternatives being compared be given a dollar value, thereby ensuring that both benefits and costs are being measured in the same units. In some cases, this is a fairly simple process. The differences in lifetime earning capacity between a college graduate and a high school dropout can be easily obtained from government statistics. When less quantifiable objectives such as appreciations or attitudes are incorporated, or when the impact of a particular project on an individual is hard to differentiate from the effects of other experiences to which he is also subjected, the problem becomes much more complex and subjective. Given solutions to these problems, the cost-benefit decision process becomes one of selecting the alternative with the highest ratio of benefits to costs using the following formula (adapted from Kaufman, 1972):

$$\sum^{T} b_t \ (1 + r_b)^{-t} \ / \ \sum^{T} c_t \ (1 + r_c)^{-t}$$

Where: T = life of project in years

b_t = annual benefits

c_t = annual costs

r = rate of discount

t = one year

The use of a discount rate in the formula is an acknowledgement of the idea that it is better to receive immediate benefits than to receive a

possibly greater benefit in the future. Basically, it is equivalent to an interest rate that might be earned by placing the money expended on the project on deposit with a bank. The use of such discount rates can have a major effect on the decision to be made using cost-benefit analysis. A study of Korean education found that the rate of return from a middle school education was greater than the rate of return from either high school or college graduation, in spite of a greater lifetime earning capacity for the rejected alternatives (Kraft, 1972).

Since discounting is not normally employed in educational institutions, it is possible to employ some simplified cost-benefit methods within the instructional development process. Figure 7 illustrates the conversion of the cost-effectiveness decision model presented in Figure 5B to a cost-benefit decision model. Part A of the figure presents the value of the resources required for each of the strategies (costs of the alternative systems) and the value of the benefits to be obtained from the adoption of any one of the alternatives at any level of output. Since each of the system prediction functions can be considered a fixed-effectiveness projection (i.e., each system is capable of producing at all levels of output), a single line will suffice to plot the benefits to be derived from adopting any of the systems. In other words, the benefits, for any level of output, is constant over alternatives. The value of this line is determined by computing such factors as the increased earning capacity of each graduate from the system, increasing the value proportionately as the number of graduates increases. (In order to keep the example simple, we are ignoring the probability that the average earning capacity of graduates might bear an inverse relationship to the number of graduates produced, due either to a shortage or to an oversupply of individuals with the same employment skills.) Once the value of each of the training systems has been determined, it is a simple subtraction problem to determine the social worth of each individual alternative; the worth is equal to the value minus the cost.

A cost-benefit decision model for the example is shown in Part B of Figure 7. The base line of student capacity is now at the midpoint of the model, with positive worth of the systems above the line and negative worth below the line. New prediction functions for each of the alternatives have been derived from it. It is now possible to see that for each of the alternatives there is a negative worth for some level of productivity or output. At some point each costs more than there is to gain. If a system with a capacity of over 200 students is not planned, there is no "good" choice among the alternatives as considered, as all systems have a negative worth below this point; alternative "C" does not even reach the break-even point until over 600 students are being handled. This conversion to a cost-benefit model brings about a reordering and shifting of the alternatives and results in a new envelope

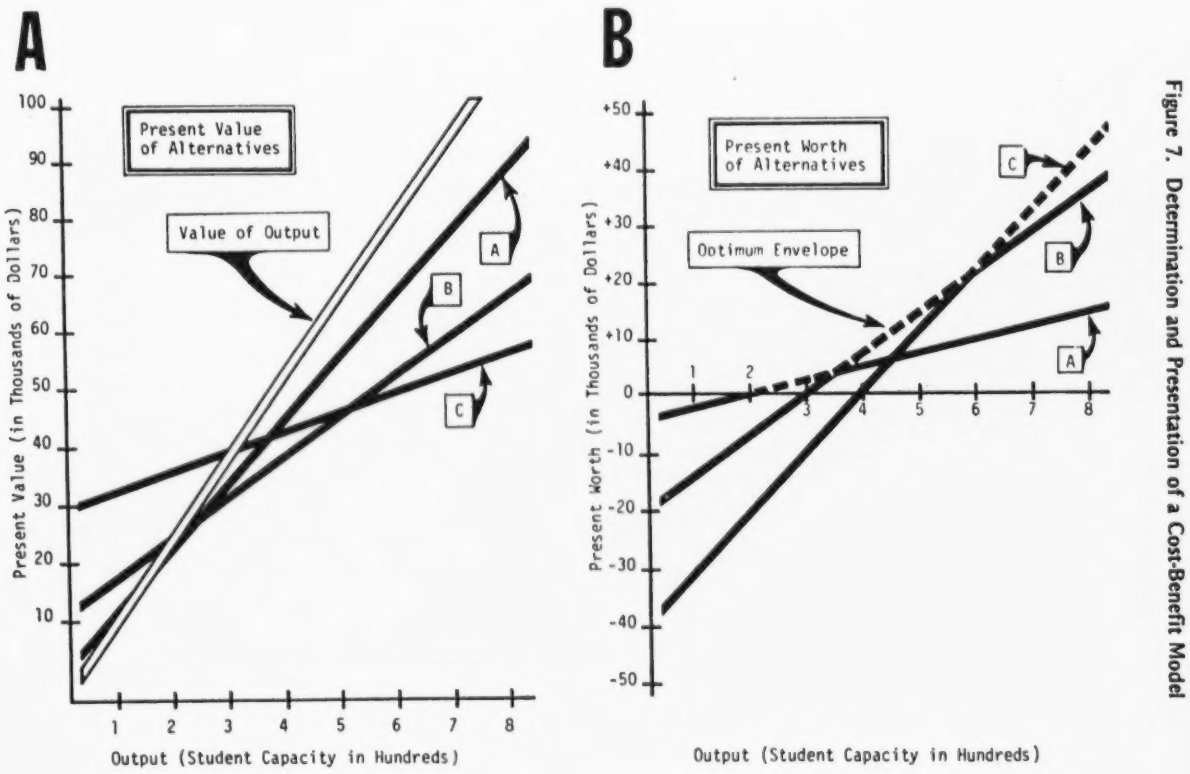


Figure 7. Determination and Presentation of a Cost-Benefit Model

of optimum choice which is shown as a broken line in the figure.

With a basic understanding of some of the available economic evaluation tools, it is now possible to turn to questions of when and where the various techniques could or should be employed.

PRACTICAL CONSIDERATIONS

Up to this point, the concern has been primarily with the theoretical aspects of economic evaluation. It is now time to consider some of the more immediate practical aspects which are of concern to the instructional developer. Such problems as selecting the appropriate evaluation technique, determining effective vs. true costs, developing the data base, and simplifying the available techniques need to be examined.

SELECTION OF APPROPRIATE EVALUATION TECHNIQUES

Different techniques of economic evaluation are appropriate to different types of questions and to different levels of the educational system (Pearson, 1973). Figure 8 illustrates some of the major differences in the point of application and therefore in the types of questions and evaluation techniques that would be appropriate for use by the instructional developer. Analysis can be conducted at the individual and at the societal levels; however, in the present context we are concerned with applications within formal education at either the institutional/school level, the departmental/unit level, or the project/team level. At the school or institutional level the types of questions which are most often asked concern whether the institution would get more from establishing an instructional development unit, from expanding the inservice education program, from establishing some special education programs, or from some other activity. This situation calls for a cost-benefit decision. At the level of the instructional development unit, when the decision is made as to which project to develop, cost-benefit decisions are also being made. At the project level, however, when decisions are made concerning the type of presentation formats to be employed, cost-effectiveness strategies are most appropriate. At all levels, we should employ cost accounting procedures to evaluate unit or project performance. None of the cost evaluation strategies can be truly effective, however, until a data base concerning instructional development costs has been developed.

Figure 8. Point of Application

LEVEL	TYPE OF QUESTION	TECHNIQUE EMPLOYED
Ssocietal		
Institutional/School	Should an ID Unit be Established?	Cost-Benefit Analysis
Departmental/Unit	Which Project Should be Funded?	Cost-Benefit Analysis
Project Team	What Medium Should be Employed?	Cost-Effectiveness Analysis
(All of the Above)	Is Unit/Team/Product Effective?	Cost Analysis
INDIVIDUAL/PERSONAL		

DEVELOPING THE DATA BASE

As was pointed out at the beginning of this paper, very little is known about the costs of instructional development. Some attempts are now being made to fill this void. Schaffer and Mory (1977) have developed an extensive cost recording system for use at the University of Delaware. Figure 9 presents the COST-ED Model developed by Education Turnkey Systems (1971) to determine the costs of development projects that they carried out for the state of Michigan. No matter what system is employed for determining the cost of a project, there are certain factors which should be included in any cost-evaluation report:

OBJECTIVES of the project being reported,
CONSTRAINTS on the freedom of choice within the project,
ALTERNATIVES evaluated in the report, and the
KEY COST FACTORS that are included in the estimates.

The first three factors have already been discussed in detail in an earlier section. "Cost factors" refers to the key costing assumptions that were made in developing the reported cost figures and will be discussed in detail in the following section.

If we are to develop an adequate data base concerning instructional development costs, with a generality beyond the institution which developed the data, certain reporting requirements must be met. Costs need to be related to resource categories, to steps in the instructional development process, and to stages in the life cycle of the project. Figure 10 illustrates the concept of project life cycle costing. Any project goes through a process of conception, life, and termination. The phases comprising this process are research and development, installation, and operation and maintenance. These phases take place at different times and call for different concentrations of resource expenditures. The major concentration of expenditures for technologically-based systems is normally during the installation phase. Under traditional strategies, the highest costs are during the operational phase. If operational costs are omitted from the estimates of project costs, therefore, a distorted picture of relative costs will be presented.

A recommended format for reporting the costs of instructional development activities is presented in Figure 11. This format displays the costs under three major sections reflecting the three phases of a project's life cycle. It might be possible, if the instructional development process followed by a project team has clearly defined and consistent stages, to subdivide the research and development phase so as to correspond to the ID process steps. In most cases, this is difficult if not impossible to do. In any case, all resources utilized in the project

Figure 9. The COST-ED Model

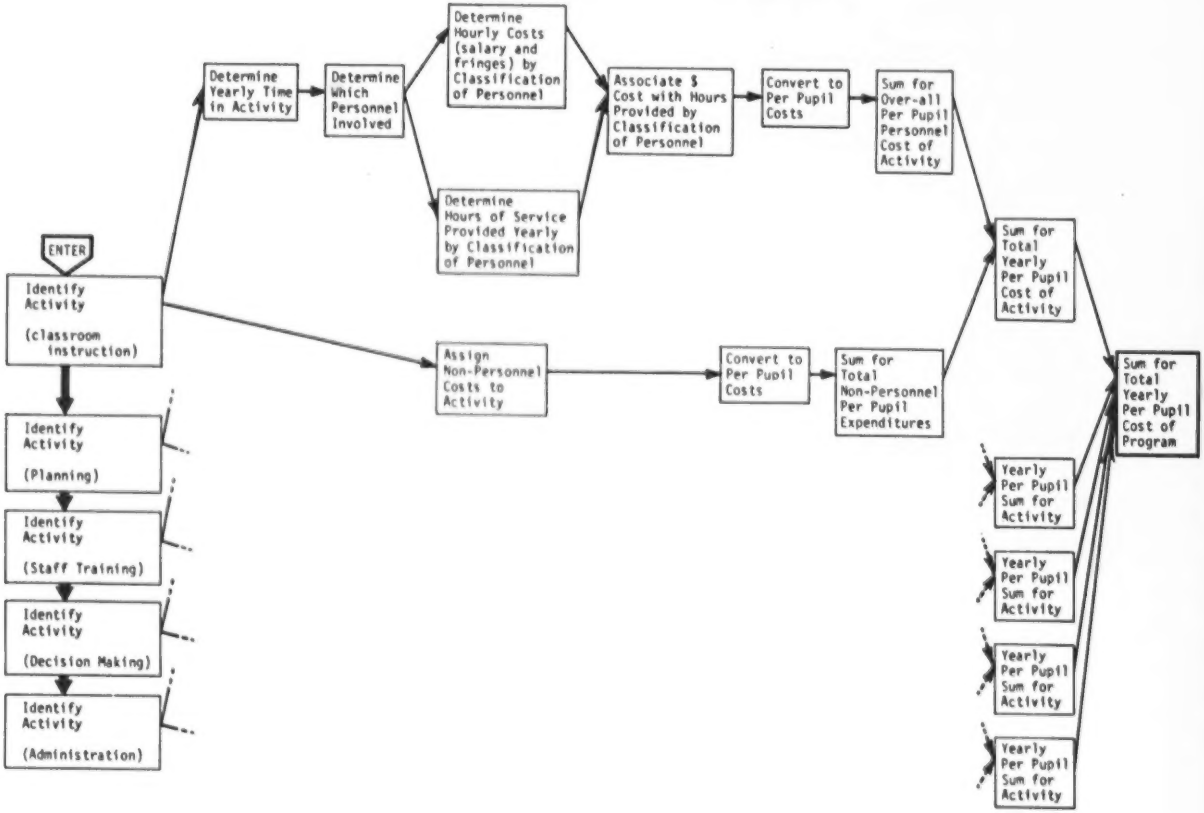

ENTER
Identify Activity (classroom instruction)
Identify Activity (Planning)
Identify Activity (Staff Training)
Identify Activity (Decision Making)
Identify Activity (Administration)
Determine Yearly Time in Activity
Determine Which Personnel Involved
Determine Hourly Costs (salary and fringes) by Classification of Personnel
Determine Hours of Service Provided Yearly by Classification of Personnel
Associate $ Cost with Hours Provided by Classification of Personnel
Convert to Per Pupil Costs
Sum for Over-all Per Pupil Personnel Cost of Activity
Assign Non-Personnel Costs to Activity
Convert to Per Pupil Costs
Sum for Total Non-Personnel Per Pupil Expenditures
Sum for Total Yearly Per Pupil Cost of Activity
Yearly Per Pupil Sum for Activity
Yearly Per Pupil Sum for Activity
Yearly Per Pupil Sum for Activity
Yearly Per Pupil Sum for Activity
Sum for Total Yearly Per Pupil Cost of Program

Figure 10. Project Life Cycle Costing

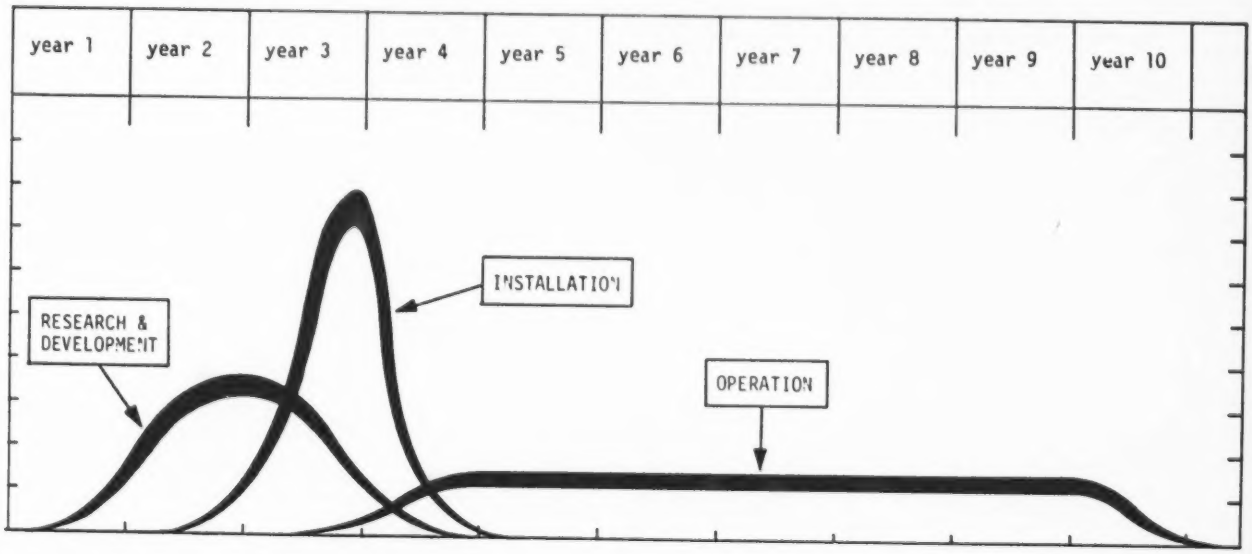
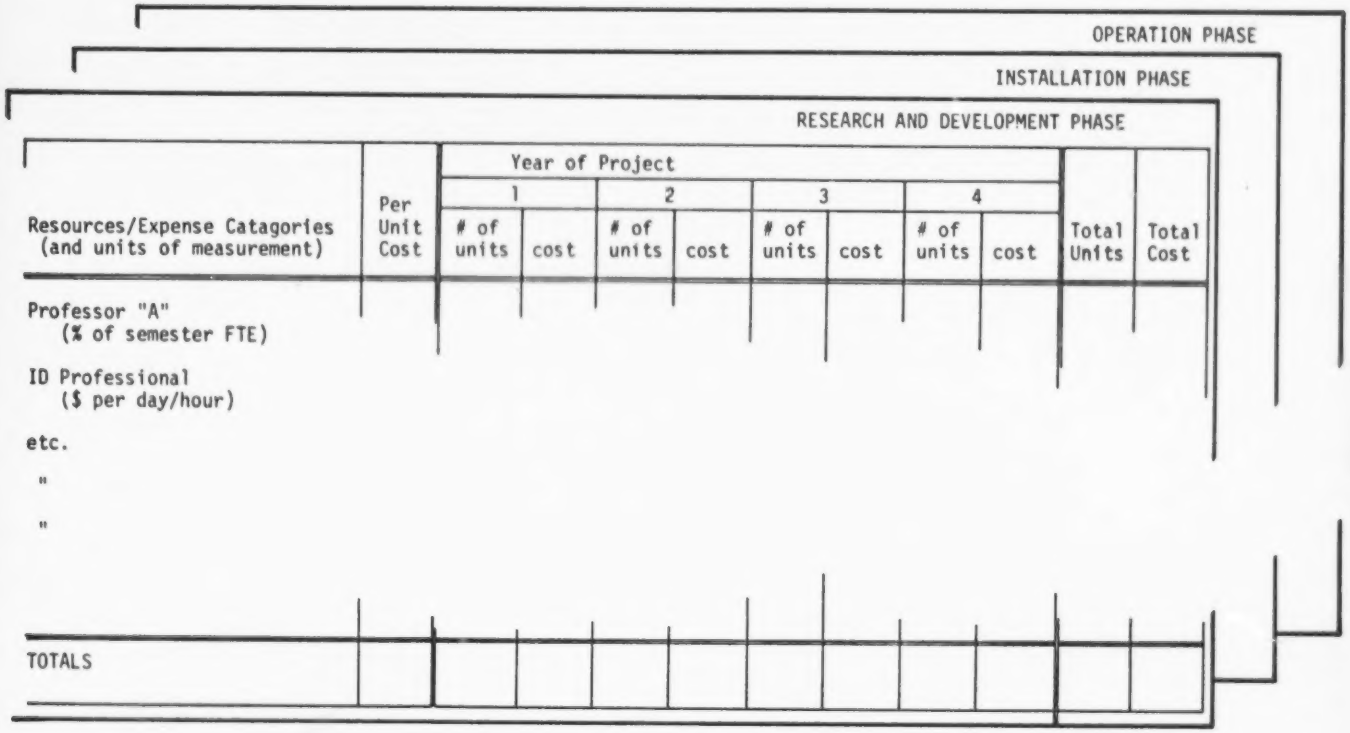


Figure 11. Suggested Format for Project Cost Reports



are fully described and the amount of each resource consumed is reported as well as its cost. This information is necessary if the reports are to be of use to individuals working in a different institutional setting or at a different time.

EFFECTIVE VS. TRUE COSTS

Up to this point, costs have been treated in an absolute sense. This is necessary if we are going to establish the true cost-effectiveness relationships for various instructional strategies. In the real world, we need not necessarily do this. Total costs are neither necessary nor desirable in the case of many of the questions which might be examined using economic evaluation strategies. The costs that are relative (effective) for a particular decision depends on the decision to be made and who is going to make the decision (Gephart, 1969). The cost of a faculty member's time is not relevant to a decision to initiate a particular instructional development project if that faculty member is not paid out of the instructional development unit's budget. This cost, however, would be of major importance at a higher level of the organization. The cost of developing a new instructional strategy is not relevant to a decision to implement or not implement that strategy if the development has already been completed. Some factors are variable – in either the cost category or the benefit category – depending on who is making the decision – for example, registration fees, which are cost items for students, are income or benefit items for administrators.

A number of cost accounting concepts are useful to the instructional developer when converting true costs to effective costs for the purpose of decision making. Some of these concepts are:

SUNK COSTS

Under this concept, any expenditure that has already been made can be treated as irrelevant to further decision-making. Therefore, money already expended on a project is not considered to be a part of the project cost when comparing that project with alternative projects. A project with a low cost-benefit ratio might very well be chosen over a more productive project because of a reduced effective cost.

INHERITABLE ASSETS

If a project can make use of resources that are currently on hand, the cost of these resources need not be included in the total cost estimate of the project.

Figure 12. Simplified Cost-Effectiveness Analysis Worksheet

FUNCTIONS	ALTERNATIVES		
	1	2	3
Needs Assessment			
Validate Objectives			
Validate Analysis			
Prototype Work			
Field Test			
Installation			
TOTAL COSTS			
OBJECTIVES			
Retention			
Time			
Attitude			

OPPORTUNITY COSTS

> The true cost of any activity is the lost opportunity to undertake some other activity. The items that would bear an opportunity cost vary from level to level within the organization. Items which would not be cost items to the instructional development unit, such as the client's time, room, space, and lights are cost items to the school administration, which has the ability to redeploy these resources in other competing activities.

The fact that so many cost items can be ignored in the decision-making process makes it even more important that complete resource consumption records be kept for all projects, even if the cost of these resources do not effect the decision-making process. Only then can a true picture of instructional development costs emerge.

SIMPLIFYING THE TECHNIQUES

The methodology of economic evaluation as it might be applied to instructional development decision-making has not been fully developed. Such evaluation techniques are primarily a way of analyzing decisions which force administrators to think through their objectives, to consider costs as well as achievement measures, and to consider alternatives to their preconceived solutions. There is a need for the development of simplified forms of the basic techniques so that developers may apply the concepts without an extensive background in economics or cost accounting. A preliminary effort along these lines is illustrated by the worksheet for performing rough cost-effectiveness comparisons presented in Figure 12.[1] The developer is to make estimates of the costs and of the outputs for each of the alternatives being considered. These are to be placed in the appropriate boxes on the worksheet. Total costs are then determined for each of the alternatives. The decision maker can then arrange the trade-offs between cost and productivity in order to select among the alternatives. As such simplified techniques are further developed, economic evaluation strategies will begin to find a greater acceptance within the instructional development process.

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[1] Dr. Thomas Schwin, personal correspondence.

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